GAS JOURNAL, AUGUST 7, 1946

VOL. 248 98th YEAR No. 4342

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Which brings us to what may be termed "allied" statistics, though it is difficult to discern any alliance between coal statistics and those relating to the Gas Industry. The amount of dirt which the Industry purchases at the present time in the form of coal denies the economies or the goodwill of a National Industry—nationalized or otherwise. The dirt sinks into the coke which the Gas Industry supplies at a price to make its sales of gas possible. The housewife knows all about this vicious circle, and we hope that in the near future the Industry will explain to the "ordinary" consumer how she stands amid the ashes.

Maybe the Ministry of Fuel and Power, if the Gas Industry sits quietly under the yoke of nationalization with the appropriate and popular serried ranks of Governmental overseers, numbered, perhaps, in millions of cubic feet of capacity, will tell the public the facts concerning the cubical capacity of an "ordinary" coke boiler and the amount of "muck" —ash and bats—it is capable of consuming without complaint. Statistics are needed. We have some of them about coal. Coal production figures during the five weeks ended June 29, issued by the Ministry, show a decline in almost every respect. The losses can only be regarded as discouraging. Optimism is out of place. Compared with May saleable output of mined coal fell from 3,702,500 tons a week to 3,394,300, and of open-cast coal from 217,500 tons to 192,300. The loss of tonnage of mined coal directly due to recognized holidays was 293,900 compared with 24,100 in May, so that if allowance is made for this the drop in weekly production was only about 38,400 tons. Voluntary absenteeism was up by 0.59% at the coal face and 0.38 for all workers; and output per manshift was down by 0.03 at the face and by 0.01 altogether. We feel sure that soon the Gas Industry, amid the throes of nationalization, will reflect on our comment that more oil will have to be used for gas manufacture.

SPOTLIGHT OF EVIDENCE

WE are getting a little tired of the constant reiteration of the theme that now that the miners are not working for private companies they will work much better. The fact is that there has as yet been no evidence of it. A year ago, the miners knew that their industry was to be nationalized. Have they been "sold" by powerful modern methods of political salesmanship the idea that they should ask for nationalization in order to end all their troubles? The agitation has been artificial in the view of many people. The testing time has now come. We have been told that it is only because they disliked private ownership that the output has fallen. A year ago they knew that their "cause" had been won; the output per man employed has not increased. At the beginning of this year, the man-power employed at the mines was 698,000. The total production was estimated to be 186 million tons. This works out at a maximum output of 266 tons a man over the year; and it includes the additional incombustible shale. But in the last years before the war the output was much greater even though far less machinery was available in the pits. Thus, in 1938 the annual output per man was 290.4 tons; in 1939, 301.9 tons; in 1940, 299.4 tons. The 1946 figure of 266 tons is no more than an estimate and is markedly greater than the actual output per man achieved last year, figures for which were not given by the Minister. There appears to be little likelihood that the supply of coal will be adequate during this coming winter.

By all means let us hope that the Minister will persuade the miners to make good the gap. He may do so, and we wish him well in his task. We fear, however, that the fault lies in those who have led the miners to believe that nationalization would bring to them a new earth, if not heaven as well. It may be well to ponder on Mr. Bowen's contribution to the debate in the House. The real cause of the poor production, he said, was the inaction of the men under 30 in the industry. In South Wales, the absenteeism of men under 30 is three times as great as that of men over 40. When he asked miners why they only worked two shifts a week, their answer was that if they worked any more there was nothing to spend their money on—so why work? In the face of that spirit, is it likely that output will go up to pre-war figures?

Is it true that the Gas Industry is expected to reduce benzole production considerably this winter? In that way the Minister may hope to save another 1,000,000 tons of coal. No doubt this measure is sound from his angle, but what of the benzole plants on which capital charges must continue to be paid and which will deteriorate when not

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in use? What of the sulphur content of town gas that could be reduced to reasonable limits by benzole extraction? Is such the sort of hand-to-mouth, short-sighted direction which we may expect from Government planning and control?

What is likely to happen to the coke market? No doubt we shall be expected to produce water gas to the limit, irrespective of the desire, even necessity, for many consumers to have coke for their appliances.

It is impossible to plan any coke sales compaign ahead under present conditions. Coke has been in a sense one of the tragedies of the war. At a time when everyone wanted coke, and when its undoubted merits have been brought before the consumer, its quality was so poor that more harm than good was done. Now that peace reigns again and war-time coke consumers might become permanent, there may well be no coke for them. The whole fuel position appears to be one gigantic muddle. Is the solution nationalization?

The key to this winter's position lies in increased output from the miners, and in increased efficiency from industry. For the work of the Fuel Efficiency Committee we have nothing but praise. We have no doubt that most of our readers will attend the October Conference in London to discuss ways and means for promoting fuel efficiency in industry and in the home. A special carbonization section of the Conference will attract gas and coke oven engineers. Whatever our views on the coal shortage and its reasons, sulphurous as may be our language when faced by shortage of coal, this is peculiarly a time when all must pull together to avoid the perils that beset us.

Staff Bonus and Salary

REFERRING to the statement at the annual delegate meeting of the Gas Staff Association that "among the many matters negotiated were an excellent war bonus and consolidation with salary and the counting of all war bonus towards pensions" ("JOURNAL," June 12, p. 971), an official of the National Union of General and Municipal Workers informed us ("JOURNAL," July 24, p. 148) that the entire negotiations were carried out by his Union. The Secretary of the Co-ordinating Committee of Gas Light Branches of the British Gas Staff Association now writes that the matter of increased war bonus was dealt with by the Association firstly with the Gas Light and Coke Company and finally with the London District Committee of the Federation of Gas Employers.

1946 "Journal" Directory

In order to keep the Directory information up to date the following alterations should be noted:

Page 6.—BATH. C. Bateman, *D.*, *G.M.*
" 12.—BRISTOL. J. Carr, *D.*, *E.* and *G.M.*
" 34.—HORNSEY. D. L. Copp, *E.*
" 46.—MARPLE. J. R. Fleming, *E.* and *M.*, vice G. E. H. Keillor.
" 88.—HADDINGTON. J. H. Fulton, *F.* and *M.*, vice A. A. Mitchell.
" 60.—MELROSE. Daniel M. Kew, *M.*

Diary

Sept. 9.—Women's Gas Council Executive Committee, Gas Industry House.

Sept. 10.—B.G.C.: Meeting at Gas Industry House, 2.30 p.m.

Sept. 12.—North British Association of Gas Managers: Annual General Meeting at Rothesay.

Sept. 16.—London and Counties Coke Association: Finance Committee, 11 a.m.; Executive Committee, 11.30 a.m.; Central Committee, 1.30 p.m.; Gas Industry House.

A Correction

In our feature "On the London Stock Exchange" in recent issues of the JOURNAL reference has been made to "Imperial Chemical Industries, controlling company of Amal, Ltd., and Welsbach Light, Ltd." We learn that all interests of Imperial Chemical Industries in Welsbach Light Co., Ltd., in so far as the Gas Industry is concerned, were acquired over two years ago by Messrs. Falk, Stadelmann & Co., Ltd. The Welsbach Light Co., Ltd., has since that date done no business.

Personal

Mr. JACQUES ABADY, K.C., who has been acting as Registrar of the Railway Rates Tribunal during the period of emergency, has resigned.

* * *

A presentation was made to Mr. J. A. GRAY, Engineer and Manager of the Ashton-in-Makerfield Gas Department, by the Ashton-in Makerfield Golf Club, of which Mr. Gray has been captain for the past six years.

* * *

Officials and employees of the Belfast Corporation Gas Department made a presentation to Mr. W. R. ARMSTRONG, Assistant Gas Production Superintendent, on his departure to take up his duties as Engineer and Manager at Coleraine.

* * *

Mr. E. H. MCCONNELL, Northern Ireland Manager of George Cohen, Sons & Co., Ltd., has been awarded the M.B.E. He played an important part in organizing the export from Northern Ireland of scrap for use in the national war effort, and also organized the Red Cross Salvage Scheme in conjunction with the Ministry of Commerce for Northern Ireland.

* * *

Lieut. V. R. BALDWIN, late of the Reading Gas Company, who has recently returned from service with the Royal Navy, has joined Cowper, Penfold & Co., Ltd. During his service he was second-in-command of a Fleet mine sweeper in home and foreign waters. Flight Lieut. P. SARGEANT, who, prior to his service in R.A.F. Intelligence, was with Bratt, Colbran, Ltd., has also joined the firm.

* * *

The Fourth Arthur Duckham Research Award made to Dr. J. E. GARSIDE, B.Sc., Ph.D.(Leeds), takes the form of a travelling fellowship, for a period not exceeding six months, for the purpose of studying recent developments in the United States. Dr. Garside took a 1st Class Honours Degree in Gas Engineering at Leeds University in 1939 and a Ph.D. Degree in 1941. He held the Leblanc Medal and a University Research Scholarship at Leeds. He was the Institution Gas Research Fellow from 1941-43, when he was appointed Assistant Lecturer in Fuel Technology.

Obituary

The death occurred on July 26 of Mr. B. J. BELL, for the past 25 years District Superintendent of the Cardiff Gas Light & Coke Company. Prior to joining Cardiff he served the Newcastle-on-Tyne and City of Birmingham undertakings. He was President-elect of the Wales and Monmouthshire Association of Gas Engineers and Managers, a past President of the Cardiff Publicity Club, and of the Cardiff Chamber of Trade, and a member of the Cardiff Civic Society. Mr. Bell served on many national Committees of the Industry, his most prominent work being that in connexion with the Industrial Gas Centres. Junior Associations in the Midlands and South Wales received his support and he devoted much time and energy in their formation and development. He was a past President of the Wales Junior Gas Association and Treasurer at the time of his death.

Letter to the Editor

The First High Pressure Gasholder

DEAR SIR,

Probably the first high-pressure gasholders erected in this country were made by us in 1907 for the Ferndale Gas Company, Rhondda, Glam.

There were two holders—each 32 ft. long and 8 ft. 6 in. diameter, to withstand 120 lb. per sq. in. pressure.

Yours faithfully,
For Willey & Co., Ltd.,
E. R. JOHNSON,
Chief Engineer.

Exeter.
Aug. 1, 1946.

The New Address of the Mining Association of Great Britain is Bolton House, 61, Curzon Street, London, W.1. Telegrams: "Minassocia, Audley, London." Telephone: Grosvenor 4801/5.

The Gas Undertakings Small Bore Rifle League, whose activities were recorded in the "JOURNAL" before the war, is to be re-formed. Secretaries of rifle clubs in the Industry are therefore asked to contact the Hon. Secretary. Mr. A. V. Allen, The British Gas Light Company Rifle Club, Bankside, Sculcoates, Hull.

Further Training and Education

We have already referred in the "JOURNAL" to the Intensive Courses arranged by the Gas Education Committee of the Institution of Gas Engineers which are being run at Bournemouth, Brighton, and Birmingham under the Government's Further Education and Training Scheme.

We learn that arrangements have been made to start a Course at the Bradford Technical College on Sept. 30, 1946. It is intended primarily for candidates who have obtained the Ordinary Grade Certificate in Gas Engineering (Manufacture) or (Supply), but candidates who have reached a standard approximating closely thereto may be admitted, subject to the approval of the Gas Education Committee of the Institution, and of the Principal of the College.

The Course will have the following time-table:

Sept. 30, 1946—Dec. 20, 1946.
Jan. 13, 1947—March 28, 1947.
April 14, 1947—May 23, 1947.

At the conclusion of the Course students will be required to pass examinations in ancillary subjects set by the College and in the main subject of Gas Engineering (Manufacture) or (Supply) set by the Board of Examiners of the Institution of Gas Engineers.

The following subjects will be studied:

	Higher Grade Gas Engineering (Manufacture)	Higher Grade Gas Engineering (Supply)
Main Subject	5 hours per week	5 hours per week
Mathematics	5 " "	5 " "
Mechanics	3 " "	3 " "
Heat Engines	3 " "	3 " "
Chemistry	6½ " "	6½ " "
Electrical Engineering ..	3 " "	—
Physics	—	5 " "

The cost of the Course will be £50, excluding text-books, which will cost approximately £10. There will be no fees for examinations in ancillary subjects, but a fee of 10s. 6d. will be charged for the main subject examination. It is proposed to arrange a works visit every week for which students will require approximately 5s. per week travelling expenses.

Intending applicants should communicate without delay with the Principal of the Bradford Technical College, Mr. H. Richardson, M.Sc., and advise the Institution that they have done so.

The College Authorities have intimated that they will do their best to assist candidates in finding suitable accommodation and should applicants take advantage of this offer they should communicate with the Principal of the College.

Awards are payable under the Further Education and Training Scheme to persons who are eligible to cover the cost of the Course, the cost of necessary text-books, examination fees and maintenance.

In regard to these Intensive Courses a great difficulty is being experienced in connexion with the supply of text-books, and for the purpose of assisting students the Institution invites the loan of copies of: "Modern Gas Works Practice," by Alwyne Meade; "Distribution of Gas," by Walter Hole; and "Science and Practice of Gas Supply," by A. Coe.

Smoke Abatement Legislation

Legislation for the abatement of smoke in this country has so far been entirely punitive, and has been confined to limiting the amount of smoke rather than to preventing its emission. It provides for penalties when smoke has been emitted in "nuisance" volume or density, but does nothing to prevent or discourage the existence of conditions which may lead to smoke.

With a view to securing a more constructive type of legislation the National Smoke Abatement Society is putting forward for discussion preliminary proposals for extensions of the Public Health Acts by means of which local authorities could obtain by-laws that will help to prevent smoke and will directly encourage fuel efficiency and coal conservation. Three sets of by-laws are proposed.

The first would require all proposed fuel-burning installations (other than domestic) to receive the prior approval of the local authority before installation and operation. This is analagous to the present building by-laws. It would not prescribe what fuels or appliances should be used, but would be concerned only with approving the plans and specifications of the applicant. In many cases this would be a mere formality; in some approval might have to be conditional on maintaining certain operational standards. This is not a new and untried idea. In most of the large cities of the U.S.A. prior approval control is in force.

The second set of by-laws is concerned with ensuring that existing fuel-burning plant shall be maintained in good working condition, shall not be overloaded so as to cause smoke or grit emission, and that surfaces and flues shall "be cleaned as often as may be necessary to ensure the efficient working of the plant to prevent a smoke nuisance."

The third set of by-laws concerns the certification of stokers and furnacemen. Much unnecessary smoke is due to faulty working and care that can be avoided, and fuel saved, by skilled and experienced stokers. Certificates would specify the class of plant the holder was qualified to operate, and would be necessary for men operating installations included in a special register kept for the purpose by the local authority. The certificates would be issued on evidence of experience and competence, or provisionally. They would not, for the present, be dependent on any tests, examinations or attendance at training courses. It is considered that by this means the status and rewards of the stoker will be raised, and that the work will become recognized as skilled and responsible.

The Society is seeking the views of local authorities, fuel technologists, industry, and the stokers before it makes its proposals more definite, and will consider any suggestions for amendment, or criticisms, at its annual conference at Brighton in October. In the meantime the draft proposals have been published in printed form, under the title "Industrial Smoke Prevention," copies of which may be obtained price 3d. post free, from the National Smoke Abatement Society, Chandos House, Buckingham Gate, S.W.1.

Location of Underground Services

The Joint Committee appointed by the Institution of Civil Engineers and the Institution of Municipal and County Engineers in co-operation with the Institutions of Electrical and Gas Engineers and the Chief Engineer, G.P.O., and later joined by representatives of the Institution of Water Engineers, the British Waterworks Association, and the Ministries of Health, Transport, and Fuel and Power, has now issued its report on the best location of underground services.

The re-development of "blitzed" and blighted areas in the built-up parts of towns, developments of the outskirts of existing towns, and the construction of new towns make it a very opportune time to introduce an agreed method for dealing with the location of underground services.

As regards electricity, gas, water, and telecommunications, the report recommends that the mains should be laid in the following order from the highway boundary to the kerb line: Nearest the boundary electricity, then gas, then water, and nearest to the kerb telecommunications. It considers that in general a width of not less than 10 ft. 6 in. on both sides of the street provides for an orderly disposition of distribution mains and services. It is possible, however, to arrange in new estates or less densely developed areas in existing towns for the location of the services required within a width of 6 ft., but this limits the space available for carrying out repairs and also makes it necessary to lay communication pipes across the street when only one main is laid.

For district heating it is considered that its concentration, bulk, and need for heat insulation indicates that provision for it in a conduit situated beneath the verge or carriageway will be necessary.

The location of transmission and trunk mains which are only likely to be laid in a small proportion of streets and these not always the main streets, should be decided locally when the needs are first foreseen. Mains over bridges should, so far as is practicable, be accommodated in pipe bays under the footways and the extent of the requirements of the various statutory authorities should be obtained in each case.

As regards subways, the report recommends that their provision should be confined to crossings under the carriageway at major traffic intersections, except in very special circumstances. Their advantages and disadvantages are discussed.

It is considered that sewers cannot be made to conform to rules of location either horizontally or vertically in the same way as is possible for other services. For example, the depth of sewers has to conform to the design of the system as a whole and there is usually not very much margin available in the choice of levels. Other points considered in connexion with sewers are the effect of branch connexions on the lay-out of sewers, separation of foul and surface water drainage, manholes, sewer subways which are normally quite impracticable and the importance of ensuring satisfactory location of the sewerage system in relation to planning proposals.

The planting of kerbside trees in town streets, except perhaps in quiet residential areas or culs-de-sac should be discontinued unless wide verges can be provided. Often improved effects can be obtained in the suburbs of towns by planting shrubs instead of trees.

The importance of the co-ordination of work is stressed and it is suggested that generally this can best be done by utilizing the services of the engineer to the appropriate highway authority. The preparation of plans and the scales to be adopted are recommended.

The Committee consider that the adoption of their recommendations will result in an orderly disposition of mains and services and avoid much of the confusion and delay in vehicular traffic which results when repairs to mains are carried out or new mains laid.

Copies of the Report are obtainable from the Secretary, Institution of Civil Engineers, Great George Street, Westminster, S.W.1, price 6d. (post free).

To relieve congestion at Nottingham's gas-works, the City Gas Committee is hoping to set up "coke depots" in three other parts of the city, namely the Meadows, St. Ann's Well Road, and Bulwell districts. This will shorten journeys considerably during periods of acute fuel shortage.

Aerated Burners of High Stability*—II.

By L. T. MINCHIN, B.Sc., M.Inst.Gas E.

The Stability of Flame at an Injector

IT is well known that burners can be so designed as to make the injector self-extinguishing—*i.e.*, so that the flame at the injector is not stable, and even if deliberately initiated will vanish along the burner tube as soon as the source of ignition is withdrawn. In order to see how this could be achieved, a study was made of the effect of air flow round a lighted jet of gas on the stability of the flame. As indicated in the previous article, however, it is not sufficient to make the flame unstable at its base; flame may also persist in the burner throat, and a second set of experiments was necessary to discover the conditions under which flame is extinguished in the burner throat.

Extinction of Flame at Base of Jet

In Fig. 2 of the previous article we sketched the probable course of the currents of air and gas in an injector, and at the same time the positions in which a stable flame could be expected to subsist was shown. Any one point in this skin of flame close to the orifice is moving approximately parallel to the axis and at the same time an ignition wave is spreading out from it through the skin, igniting the unburnt gas as it comes from the nipple. So long as the velocity of flame propagation exceeds the linear velocity of this element of gas the flame will remain sheathing the gas jet. Once, however, the velocity of the gases in the flame sheath exceeds the flame velocity the flame will no longer be stable at the base of the jet.

Clearly, the velocity of the gases in the flame sheath is dependent on, and intermediate between, the axial velocity of the jet and the velocity of the surrounding sheath of air. The axial velocity depends mainly upon the pressure and density of the gas supplied, but the velocity of the surrounding air is influenced by a number of other factors, and it is these which are chiefly made use of in designing the self-extinguishing injector.

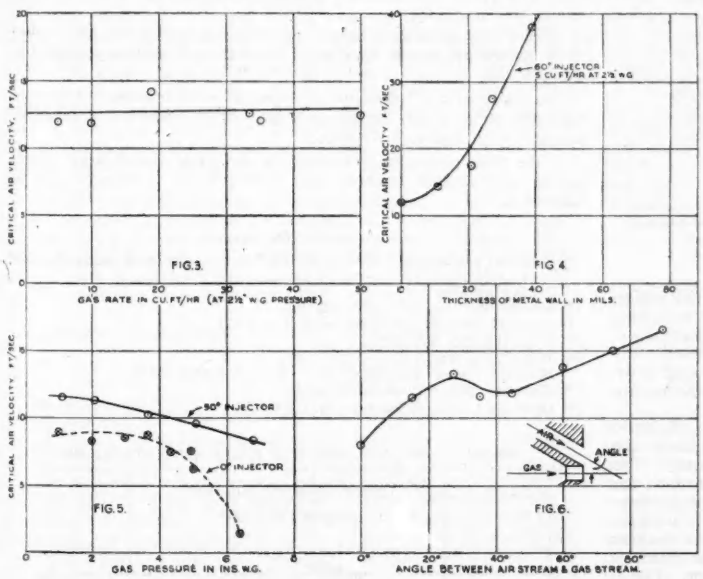
The process can be studied in an apparatus somewhat resembling a laboratory blow pipe, but differing in that gas is fed into the centre and air into the surrounding annulus. Both air and gas can be metered, and the air and gas jets are removable so that different kinds of nozzle can be tried.

When this experiment was made, prior to the war, by Mr. E. C. Roberson and the author, a very good confirmation of the theoretical discussion was obtained. In each experiment the air velocity was increased to the point at which flame blew off to a position an inch or so beyond the nozzle. This was called the "critical air velocity," and was found to correspond very well with that actually drawn into a practical self-extinguishing injector.

It might have been expected, perhaps, that in such an apparatus the blow-off point would depend on the ratio of air to gas. If, however, as we have just supposed, the blow-off point depends mainly on air velocity this would not be the case. In Fig. 3 the critical air velocity has been plotted against the gas rate provided by a series of gas nozzles of varying diameter at the same supply pressure. It will be seen that the air speed needed to produce blow-off is virtually independent of the volume of gas. Again, the effect of gas velocity is shown in Fig. 5; as would be expected from our theory the higher the gas pressure (and hence gas velocity) the lower the critical air-speed at which blow-off occurs. Fig. 4 shows the effect of the wall thickness between gas and air streams; above 10 thousandths of an inch the air speed required rises rapidly, due to the formation of a pocket of stationary gases in the wake of the wall thickness which enables the flame to establish itself.

Since the desired effect of the air stream is to increase the velocity of the gas-air interface it is to be expected that an increase in angle between the two streams will reduce the resultant velocity and hence make blow-off less likely. Fig. 6 indicates that this is broadly true. Finally, rise in temperature causes a rapid increase in the flame velocity, which one would expect to reduce the likelihood of blow-off. The critical air speed rises very sharply with increase in temperature, 300° C. rise causing an increase to 300%.

From these experiments it can be seen that to make a jet unstable it is important to shape the nipple with an acute angle at the apex and little or no "flat" between the sloping side of the cone and the orifice. It is also very desirable to keep it cool. (If, however, one is considering a luminous flame in which it is desired to *prevent* "blow-off" a flat or even a dished exterior would seem to be desirable.)



Prevention of Flame in the Burner Throat

Even though the flame has been driven from the injector nipple, further precautions are still necessary to prevent the flame lingering, roaring and turbulent, in the burner throat. It is easy to see that in the case of a simple burner, with a single injector orifice, the speed of travel will be highest at the central core and slowest next the walls; and it is here, where the speed is slowest, that the fastest burning mixture is likely to be found. Evidently it is there that the flame will form, and most of the devices designed to prevent it have been essentially, means of spreading the jet so that it fills the throat rapidly and eliminates the slow-moving, air-rich region. A rather narrow throat is almost invariably necessary. The various methods of achieving this result which have been proposed at one time or another are shown diagrammatically in Fig. 7.

In some of these, such as (b), (c), (d), and (e), the way in which the jet is spread out is obvious from the diagrams. Zollikofer and Raeber (7) used a rifled cylinder which imparted a rotary motion to the jet, while the Eschebach burner has a blunt pin incorporated. Two G.L.C.C. designs (8) (9) are shown in (d) and (e) and these, although they have not proved of great practical importance, illustrate the theory very well. If the holes are too far apart a slow-moving region forms in the centre, and flame then persists at the axis of the burner. The Junker and Ruhr burner is somewhat different, since it is alleged to depend on a supersonic vibration set up by the assymmetric obstruction placed just behind that orifice (10). Finally, the double-injector type shown at (a) in Fig. 7, described by Frei in 1931 (11) and now made in this country under the name "aeromatic" (12), can also be regarded as a jet-spreading device. The air drawn in at the first air-port travels along the subsidiary throat until the velocity and the mixture proportions have been equalised, so that when it emerges at the second air port the initial fine jet has already been enlarged to a cylindrical stream only a little narrower than the second throat into which it is directed.

Rather surprisingly, it was pointed out by Louis and Glachant in 1937 (13) that a self-extinguishing injector could be made by employing none of these special devices, but instead paying particular attention to the dimensions of the throat and position of the injector nipple. It is this type which has been studied in most detail at Watson House, and which was also fitted to some cooker hotplates just prior to the war.

* Communicated by the Watson House Research Department of the Gas Light and Coke Company.

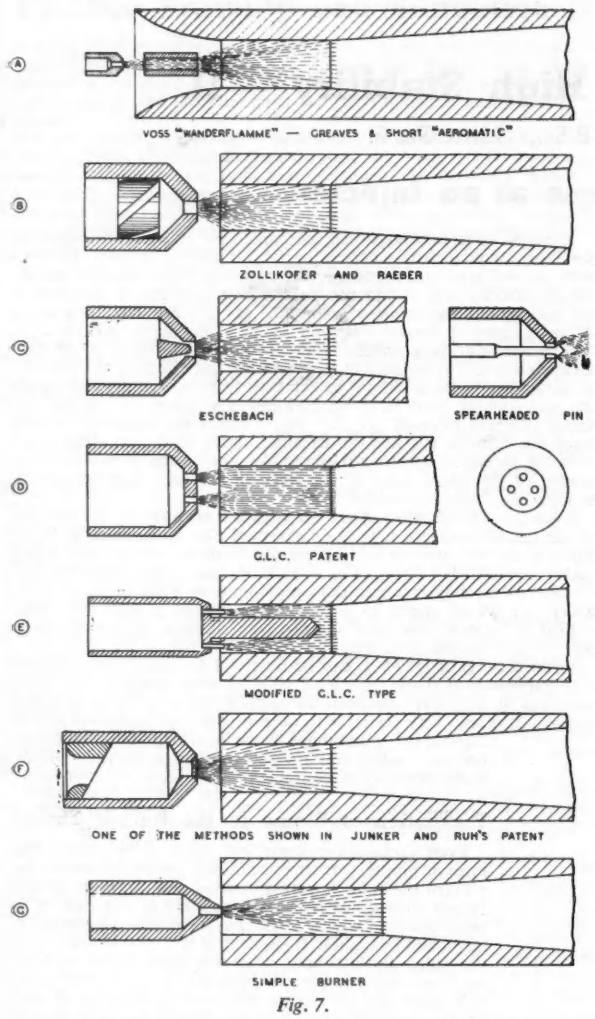


Fig. 7.

Bearing in mind that the avoidance of slow-moving, air-rich region is the prime necessity, it will be clear that the accurate mounting of the injector nipple on the axis of the burner is of first importance. It is also essential that the throat should be machined smooth; any protuberance such as a casting-fin would cause a local slowing down at which flame would be retained and this would serve as a permanent ignition-point for other regions.

It is also important that the throat shall be parallel and of sufficiently small diameter to maintain a high velocity throughout. Finally, the gap between injector nipple and burner throat must be small. The critical values of these three dimensions have been determined for 500 C.V. gas and these are shown in Figs. 8 and 9. Throat diameter and throat length are to some extent interdependent—*i.e.*, a bigger diameter is permissible if length is greater. One of the disadvantages of a throat which has no parallel section at all is that the diameter has to be so reduced that the aeration becomes very poor. Fig. 9 shows the air-gap permissible, and it will be seen that this is a rather critical dimension. Two upper limits are given, one for an injector self-extinguishing at 3 in. W.G. pressure and another for use if self-extinction is to be maintained down to 1 in.

Other Types of Self-extinguishing Injector

It is much more difficult to give exact dimensions for the other types shown in Fig. 7 since they are all more complicated.

With regard to the Zollikofer type (8b), however, some figures for throat diameter are shown in Fig. 10. Two practical examples are shown in Fig. 11, which represent gas rates of 20 and 45 cu.ft. per hour. This type of injector is often of use where a very short burner is required. The swirl, imparted to the jet, promotes very rapid mixing, and a parallel section to the burner throat can be eliminated if necessary. As will be seen from Fig. 10, however, the use of a parallel section enables a considerably wider throat to be employed with consequent improvement in the aeration.

The principles upon which a self-extinguishing injector depends for its operation are fairly well understood. Whether one decides

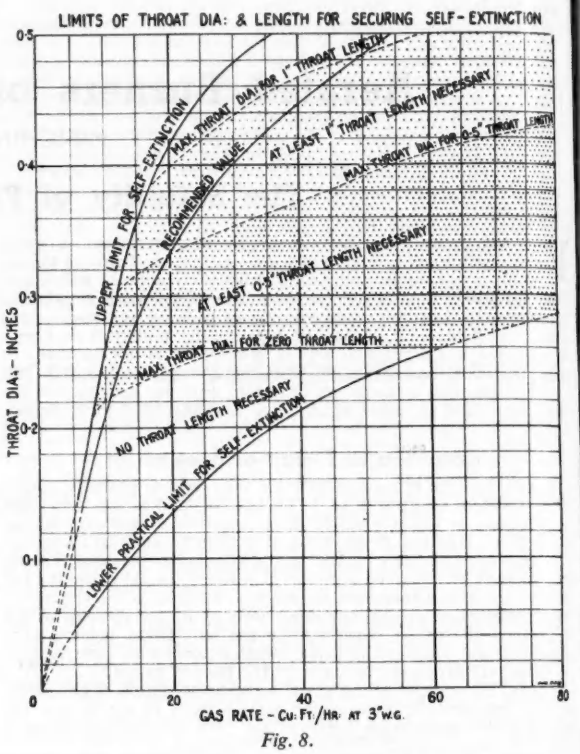


Fig. 8.

to employ such a burner is largely a question of whether the advantages to be gained are worth the cost of the increased accuracy needed in manufacture.

The study of the behaviour of blow-off is of interest not only in this connection; it also throws some light on the behaviour of luminous jets near their limits of stability.

In the third article of this series the design of flame-proof burner heads, fully-aerated burners and "perignitable" burners will be discussed.

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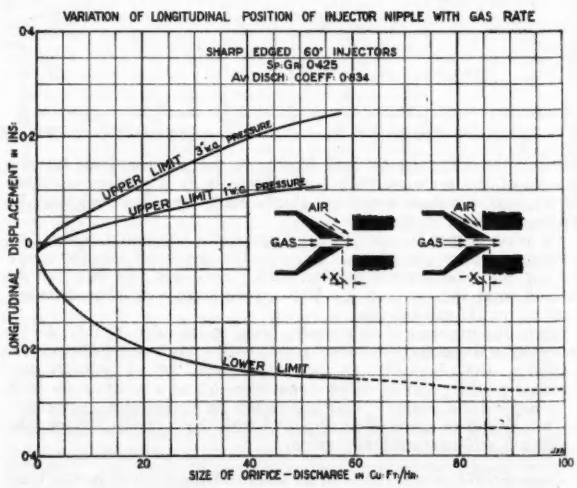

Fig. 9.

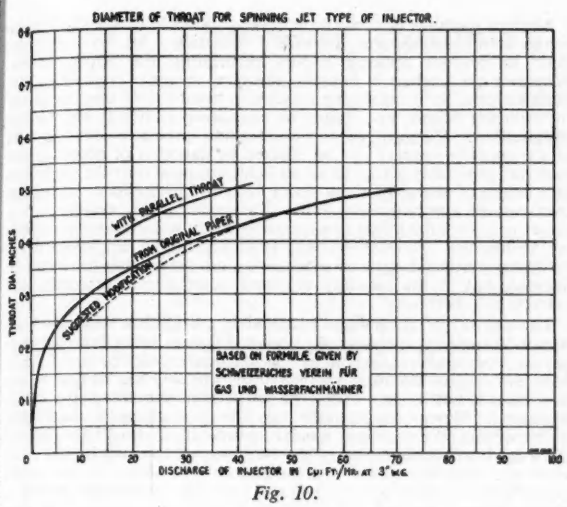
DIAMETER OF THROAT FOR SPINNING JET TYPE OF INJECTOR.
THROAT DIA. INCHES
WITH PARALLEL THROAT
FROM ORIGINAL PAPER
SUGGESTED MODIFICATION
BASED ON FORMULÆ GIVEN BY SCHWEIZERISCHES VEREIN FÜR GAS UND WASSERFACHMÄNNER
DISCHARGE OF INJECTOR IN Cu. Ft./Hr. AT 3" W.G.

Fig. 10.

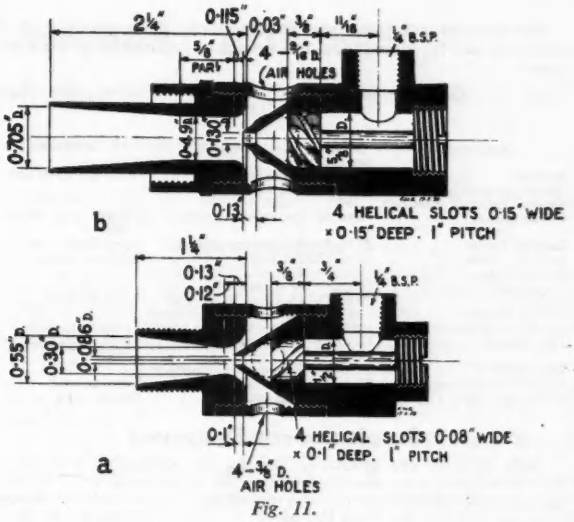

Fig. 11.

Commercial Uses for Gas*

By W. JOHNSON and W. F. MOORE

Concluded from p. 195

BOILING-TABLES are required to perform very heavy duties—*e.g.*, cooking of stews, soups, and vegetables. In vegetable boiling, it is our experience that the average hotel prefers to use a boiling-table. The " solid top " type finds favour with chefs, but for making small quantities of sauces, custards, &c., a section of the open flame-type hotplate should be provided for economy. For boiling green vegetables allow 1½ lb. per gall. capacity, and 4 lb. per gall. for roots, with vessels not usually larger than 5 to 6 gall. A separate stock-pot stove should be provided in all but the smallest kitchens, with vessels of from 8 to 20 gall. capacity.

Steaming Ovens

Preferably of small capacity, these are multiplied according to the number of meals, thus enabling different foods to be cooked without interruption—*e.g.*, suet puddings, 2 to 3 hr.; potatoes, 20 min. (Not all varieties of potatoes are suitable for steaming—*e.g.*, " King Edwards " tend to discolour and should, therefore, be boiled.)

Capacities for root vegetables:	24 lb. per cu.ft., or 13 lb. per sq.ft. tray area.
Capacities for puddings:	30 × 3 in. diameter per cu.ft. or 50 × 2 in. portions in 3 in. diameter cylindrical containers.
Capacities for fish:	4½ lb. per cu.ft.

Grillers and Toasters

These should be of robust construction with separately controlled burners for economy in use on the larger sizes. Various types are available to suit the requirements of particular kitchens, and for toasting and light grilling a shallower appliance is used. Where grills are a speciality, the under-fired or " Silver grill " type may have to be considered. Average capacities can be judged at 8 to 10 steaks per 8 min., or 6 slices of toast (each 5 in. by 4 in.) per 2 to 3 min. for a grilling space of approximately 150 sq. in.

Frying Ranges

For fish and chipped potatoes and other foods calling for deep-fat frying, ranges with integral hood or screens are preferable to open pans on the boiling-table. Hinged pan covers and fish racks should be included. With an approximate depth of 2 in. of fat or oil, average capacity per sq. ft. of pan area is 2.75 lb. of fish, and 3 lb. of potatoes, and the cooking time is about 5 min.

Bain-maries

Open type bain-maries, for use with the usual vessels, are a valuable asset in the kitchen. Usually, about half the length of the boiling-table will be sufficient capacity for maintaining reserves of cooked foods waiting to be transferred to the serving counter when required. There is a tendency in most hotel kitchens to under-estimate the size of this appliance.

The serving of meals may be from the side or end of the kitchen, but in suitable premises the equipment used is housed in a separate room adjoining the dining-room.

The major appliance is the hot closet of counter height, for warming the large number of plates required. It has carving recesses on top, and hinged or loose covers, with or without balance gear. Bain-maries may be fitted in the hot closet top or as a separate section, complete with the requisite number of vessels for vegetables, soups, and sauces. Actual requirements can usually be met from manufacturers' lists, after careful study of the type and number of meals to be served. The internal depth should not usually exceed 27 in. unless doors on both sides are provided, as difficulty is experienced in reaching to the back of the bottom shelf. A tray rail or shelf for the waiter's use should be considered where the appliance is not fitted against a wall, or where otherwise a back skirting should be fitted.

A section of unheated counter top, as a continuation of the hot closet, is required for cold dishes, with open shelving beneath.

Water-boiling Appliances

The three types of water-boiling appliances are:—

(1) Pressure boiler operating at 3 to 4 lb. per sq. in., and with automatic water feed valve.
(2) Overflow type with narrow water-ways and automatic water feed tank.
(3) Bulk-storage urn.

The pressure boiler and the overflow type are the more suitable for continuous steady demands, the below-counter models allowing more room on the counter top for serving. Output should be assessed on the continuous delivery rating, with a margin to allow for a falling-off in flow as the descaling period approaches. Requirement for tea-making in pots is approximately 1 pint per person, allowing for rinsing of pots and jugs, and spillage. Jacketed hot-water urns for storage of coffee and milk can be attached or separate according to the requirements of the particular lay-out. Interior linings of glazed earthenware, stainless metal, or heat-resisting glass, are all satisfactory, the choice being mainly influenced by cost. The capacity required varies considerably, but an allowance of ½ pint per person is a reasonable estimate. It should be emphasized that milk must be heated prior to transfer to the urn, which is intended only to maintain the temperature.

Still-Room

Where space permits the serving of hot and cold drinks and quickly-prepared light dishes is removed from the main service room. The gas equipment for the still-room would comprise some or most of the following:—

Café boiler	With coffee and milk urns.
Toaster	For bread, scones, &c.
Hot closet	For warming plates, &c.
Egg poacher.. ..	Sometimes heated on top of toaster.
Egg boiler	Can also be attached to the café boiler.
Small boiling-table ..	For heating milk in a double sauce-pan or making coffee if not dealt with by café boiler.

* From Communication No 297 of the Institution of Gas Engineers: presented June, 1946

Refrigerators are sometimes used to hold dairy produce in the still-room and for preparation and storage of cold sweets in the service room.

TABLE 8.—*Gas Consumptions of Appliances* (*Full-on Gas Rates*: 500 *C.V.*)

Appliance	Gas Rate (cu.ft. per hr.)	Capacity	Remarks
Ranges	200	Average	Per single oven unit
Ovens (internal heating)...	40 to 70	5 to 10 cu.ft.	—
Ovens (external heating)	65	7 cu.ft.	—
Ovens (pastry)	8 to 10	Per sq. ft. sole area	2 decks 7 in. to 12 in. high
Boiling Tables	25 to 35	Per burner average	Open flame type
Boiling Tables	80 to 130	Per unit	Solid top type
Boiling Pans	5 to 6	Per gall.	—
Steaming Ovens	60 to 90	4½ to 7½ cu.ft.	—
Grillers	70 to 150	18 in. to 36 in. wide	× 15 in. deep
Frying Ranges	0.36	Per sq. in. pan bottom	—
Stock Pot Stove	100	24 in. × 24 in.	Treble concentric
Hot Closets	12 to 15	Per ft. run average	Allow extra for bain-marie
Hot Closets	5	Per sq. ft. top surface	—
Water Boiler (for teas, &c.)	75 to 400	120 to 700 pts. per hr.	Instantaneous
Coffee and Milk Urns ...	10 to 20	Average	Storage only

Supplementary Equipment

Dish washers are gradually gaining in popularity, and should always be considered where more than 100 meals are served. There is considerable difference of opinion regarding the superiority of one type over another, so that from this aspect a neutral attitude is the wisest. Our main interest is in the hot-water requirements, which differ slightly in each case, but warrant special attention. There are two distinct types:—

(1) The semi or fully automatic high-pressure spray type (enclosed).

(2) Open sinks with revolving brushes or a mechanically induced "surge" of water.

With each type, two water-heating units are normally required, one for washing water at 140° F., and one for rinsing and sterilizing water at 190° F.

The high-pressure spray type for washing comprises a hot-water storage tank in the base of the machine, the hot water being pumped through spray nozzles on to the crockery in a chamber above. The water then returns to the tank by gravity. Unless the machine incorporates a water-heating unit for the wash tank (which can be either gas or steam heated), hot water from a storage system will be required to fill the tank before operations are begun.

For rinsing, hot water at the higher temperature is required with both types. This can be obtained from a direct type of heater fitted above the machine, or from a "secondary" circulating boiler and storage tank to boost the hot water (140° F.) to the higher temperature required (190° F.) A "divided" storage cylinder may sometimes be used for this purpose when the distance from the machine is only a few feet. In both types the rinse water used flows to the wash tank and in the case of the high-pressure spray is sufficient to maintain the temperature whilst the machine is in constant use. An additional heater is usually incorporated in the open sink type machine for this purpose.

When estimating for hot water supplies to dish-washing machines the actual type and size of wash tank must be known. Capacities of these machines are stated in the number of "pieces" per hr., including plates, cups, and cutlery. The quantity of high-temperature hot water varies between 15 and 20 gall. per 1,000 pieces per hr. It should be stated that where a dish-washer is installed, separate sinks and drainers will be required for washing-up fine glass-ware, &c., and for crockery washing-up in the event of a breakdown of the machine. Hot water requirements for all purposes will very considerably according to the facilities provided and numbers served, &c., but will be in the order of 1 gall. per meal.

Steam Cooking

The initial cost of installing steam for cooking is high by comparison with individually heated gas appliances. However, it has some advantages, particularly when a central gas-fired boiler is used, with its attendant benefits of fully automatic control. Such an installation would work at a pressure of between 15 to 30 lb. per sq. in., and apart from the usual boiler mountings, would probably include in the gas supply system a governor, a flame failure cut-off device, a low-water cut-off device, and an automatic control valve (steam pressure operated). Water supply is usually through an automatic feed pump (steam or electric). An automatic damper fitting in the flue is optional.

TABLE 9.—*Steam-heated Appliances Working Pressures and Steam Consumptions*

Appliances	Working Pressure (lb. per sq. in.)	Maximum Steam Requirements (lb. per hr.)	(Capacity Rating)
Steaming Ovens ...	5	5	Per cu. ft.
Boiling Pans	15	2	Per cu. ft.
Hot Closets	15	2	Per sq. ft. top surface
Bain-maries	15	3 to 4	Per sq. ft. top surface
Water Boiler (Tea) ...	15	1.7	Per gall.

Maintenance costs are likely to be high unless the installation is well planned, with particular attention paid to lagging, steam trapping and utilization of condensation steam where possible.

Modern methods of ventilation make it possible to site the kitchen nearer to the dining-room, instead of operating a lift from an upper floor to prevent cooking odours permeating the public rooms. Wherever the kitchen is housed, adequate means of ventilation are most essential for maintaining reasonably comfortable conditions and for reducing fatigue, and should be considered even with the smallest installations. Removal of the combustion products and the bulk of the cooking vapours can be effected by canopies of non-corrosive material, preferably glazed to admit light, arranged over the appliances at a height of about 6 ft. 3 in. from floor to lower edges and with an overspan of approximately 9 in. The inside edges should form a gutter to collect the initial condensation which will eventually disperse on heating-up. Natural draught flues should be employed where sufficient vertical height is attainable and horizontal runs can be avoided, but in the majority of cases some degree of mechanical extraction is necessary.

The number of air changes required in the kitchen will vary from winter to summer, the generally accepted figures being from 20 to 40 per hr. Natural ventilation of the kitchen should be provided at high level to give the usual 3 to 5 changes when the mechanical extraction plant is not in use. Adjacent store-rooms should receive similar treatment. Having regard to the high rate of air change in the kitchen with mechanical extraction, special consideration should be given to the local heat requirements of the building, as this will be increased when the extraction plant is in operation. Auxiliary heating under separate thermostatic control is thus a necessity, and should provide a positive flow of warmed air towards the kitchen to ensure the retention there of all kitchen smells. Proper ventilation reduces condensation, but it will not prevent this nuisance unless the fabric of the building is properly insulated. Thermal insulation is the best remedy.

The benefits to be derived from a well designed and properly installed ventilation system, in increased health and efficiency of kitchen staff, and improved conditions for an establishment's patrons, undoubtedly justifies the initial expense.

Advantages of Gas-heated Catering Appliances

Initial cost and installation are generally cheaper than with either solid-fuel or electric appliances.

General appearance is more or less equal with all fuel-heated equipment.

Speed in heating-up from cold is quicker than with solid fuel or electricity. When solid-fuel appliances are left alight they are always ready, but for a sudden emergency after a quiet spell neither solid-fuel nor electric appliances can compete with gas.

Flexibility of heat control is vastly superior with gas. This will be even further enhanced if simple but positive ignition devices are developed.

Pan stability.—Solid hotplates have a great advantage. Further improvement is needed on open type hotplates, which must at the same time retain their higher efficiency for intermittent use.

Ease of cleaning of appliances, by use of smooth flowing designs, is a common development with all fuel-heated equipment. More attention is required with gas cooking equipment to prevent grease baking on to the heated surfaces. These should be either hot enough to burn off grease, as with solid-fuel appliances, and hotplate units of electric appliances, or the surrounding parts should be designed to remain cooler than the baking temperatures of cooking fats.

Temperature control of ovens, by variable thermostats in convenient positions, and for steaming ovens, hot closets, &c., with the fixed-temperature type, gives further advantages to gas. Overheating or temperature fluctuation is prevented without loss of speed in heating-up.

Maintenance.—With proper use, solid-fuel appliances have low maintenance costs, due to their heavy construction, but misuse and consequent overheating, together with flue maintenance, leads to heavy costs. Electric appliances have high maintenance costs, due mainly to repairs or renewals of heating elements. Replacement of parts on gas appliances is comparatively rare, and simplification of design has reduced these costs to a minimum.

Construction of catering appliances requires further attention by designers and manufacturers in some directions—*e.g.*, standardization of heights and depths, with unit construction, would enable individual appliances to be added, when justified by increased demands. Thus the genral appearance of the installation would remain unimpaired.

Running Costs.—The most economical kitchen is one which has the correct balance between the amount of equipment and the number of meals served. To this end, unnecessarily large cooking units should be avoided. On the thermal basis, solid fuel is cheaper, and electricity dearer, than gas. The approximate cost of gas for restaurant catering averages 10 cu.ft. per meal served.

Company's Tariff.—The following scale of discounts is allowed for hotel and restaurant use:—

Therms (per month)	Per cent.
For the first 25 ..	*Nil*
„ next 100 ..	6
„ „ 125 ..	10
„ „ 250 ..	15
„ „ 500 ..	20

The Gas Industry in Sweden: 1939-1945*

By ARVID HEDBERG

Secretary, Swedish Gas-Works Association

THE Swedish Gas Industry has been spared any direct hostile attack during the recent war. The measures taken to meet possible war damage were certainly not of such a special character as to be mentioned in this summary.

As Sweden is dependent upon imported coal, the war has indirectly brought several problems to Swedish gas-works through their isolation from other countries and their consequent lack of coals. As early as 1940, the importation of coal decreased to about 50% of the pre-war amount, but then remained nearly unchanged until the end of 1944. In 1945 coal imports decreased to less than 5% of the pre-war amount. Coke imports at the same time showed a drop nearly equal to that of coal imports. On April 12, 1940, coal and coke were confiscated by the Government. The Gas Industry was given a privileged position, and the coal supply to gas-works increased up until 1945, when a marked reduction became necessary. Other industries, as well as housing estates in towns, were compelled to use wood instead of normal fuels, *i.e.*, coal and coke. Gas production showed a fairly steady increase until the end of 1942. In 1943, the increase had to be stopped, and in 1944 and 1945 gas production had to be decreased. Coke production was almost constant—if breeze be included—until 1944. In 1945, the output of coke decreased comparatively more than the coal consumption. The number of gas meters has increased in proportion to the number of new dwellings. The facts stated above are illustrated by the following Table:—

TABLE 1.—*Swedish Gas Industry Statistics*

	Year	1939	1940	1941	1942	1943	1944	1945
A	Imports of coal to Sweden (Thou. tons) ...	6,342	3,996	3,160	2,705	3,561	2,348	294
B	Imports of coke to Sweden (Thou. tons)	2,339	1,724	1,643	1,186	1,242	1,214	110
C	Coal Carbonized at Gas Works (Thou. tons)	665	657	673	717	706	731	549
D	Production of gas at Gas-works (mill. cu. ft.)	8.578	8,578	9,002	9,778	9,813	9,319	8,472
E	Production of coke at Gas-works (Thou. tons)	449	400	398	433	430	451	268
F	Number of gas meters at the beginning of the year (Thou.) ...	518	545	556	565	576	591	606

In 1939, the average gross calorific value of the gas was 500 B.Th.U. per cu.ft. at 60° F. and 30 in. Hg. Successively it has been decreased to about 450 B.Th.U. per cu.ft.

Raw Materials

At the beginning of the war the Gas Industry had larger stocks of caking coals than in normal times. However, as these stocks were decreasing, it was necessary to use more and more non-caking coals. When the limit of the caking power of the coal mixture was reached, gas-works with vertical chambers had to begin to carbonize non-caking coals separately. Since then these coals have not been crushed before charging. Even gas-works with horizontal chambers have been obliged to use relatively large quantities of non-caking coals. In order to clear the discharge of the coke it has been necessary to make a bed of a caking mixture, upon which non-caking coals have been charged. Caking coals were rationed from the beginning of 1944, and were then chiefly assigned to gas-works with horizontal retorts. At the end of 1944, coal imports stopped entirely, and since Jan. 1, 1945, all kinds of coal have been rationed to the Gas Industry. For the first half of 1945, a quantity of coal, equivalent to 80% of the half supply in 1942, was assigned to each gas-works, and for the second half of 1945, as well as for the first half of 1946, the ration was equivalent to 60% of the half quantity of coal carbonized in 1942.

Only the three largest gas-works, *i.e.*, those at Stockholm, Göteborg and Malmö, have water gas plants, which normally are in reserve. These gas-works at first turned mainly to water gas, produced from coke, to compensate for lack of coals. Further these three gas-works together started to produce peat-coal according to a method invented by the Stockholm Gas-works. Air-dried peat usually contains 40% of water and 32% of oxygen (dry basis), and for this reason is not suitable to carbonize in its raw state. However, if this peat be heated in vertical shafts to a temperature of 220° C., at which temperature most of the water and about 10% of the dry substance are removed, peat-coal with 26% of oxygen is obtained as a final product. Peat-coal gives more gaseous therms per ton than fossil coal, and the gas has a calorific value of 460 B.Th.U. per cu.ft. The by-products of peat-coal are similar to those produced from gas coals. The plants for producing peat-coal were started at the beginning of 1945, and commenced operating last autumn. The plants have been erected in southern Sweden, where there are large peat-bogs, and they cost about 4.5 mil. Swedish crowns. The plants are calculated to produce 80,000 to 110,000 tons of peat-coal a year from 150,000 tons of air-dried peat as raw material.

Carbonization of Wood

At the very beginning of the war, tests were started on a small scale, particularly by small gas-works, on the carbonization of wood in order to collect experience that might be of use in a more critical coal situation. Since coal rationing began, small and middle-sized gas-works have been carbonizing considerable quantities of wood. For the most part the wood is completely gasified by blowing steam into the chambers. For gas-works having no separate water gas plant, wood offers a better possibility of making water gas than does mineral coal.

In order to keep the calorific value of gas at a suitable level, in spite of the addition of water gas, various kinds of tars and fuel oils have been used as carburetting agents. The small gas-works inject the oil together with steam into the chambers which are charged with wood. Importation of oil started again last autumn to a large extent, but imports of coal are still very low. Just now, early in 1946, oil imports seem to be stopping again, and this will perhaps cause new problems for gas-works.

During the war a plant was started for the production of oil from bituminous slate at Kyarntorp, near Orebro. As a by-product a considerable volume of non-condensable combustible gases (about 1,765 mill. cu.ft. a year) are produced. Since the early part of 1945, Orebro has been supplied with gas by means of a high-pressure main, 10½ miles long. The ovens at the gas-works have been shut down since that time. Gas consumption in Orebro is normally about 250 mill. cu.ft. a year, but is now rapidly increasing since the introduction of the slate-gas, which has come into extensive use for hot water and house heating installations.

Increasing Demand for Gas

In Swedish towns most houses are equipped with installations for central water heating. On account of the scarcity of coke and the difficulty of providing wood, which is, above all, a question of transport, the authorities at the end of 1940 prohibited the supply of central hot water. The housewives then proceeded to heat water on their gas ranges, which increased the demand for gas by 10 to 15% on the total supply from the gas-works. However, the real saving of fuels, in the form of coke and wood, was considerable compared with the increase in gas consumption.

Even at the end of 1939, industries which had previously been using fuel oil, had to use other fuels. Most of the demand was then met by gas generated from wood in separate producers, but the gas-works themselves had to meet a substantial part of that demand.

During the war Sweden was forced to use wood and charcoal as fuel for motor-cars. With these fuels, starting takes a long time. Town gas has, therefore, been used for motor-cars, for which quick starting is desirable. For this purpose eight gas-works erected stations for compressing gas into steel tubes. Gas from the distribution system has also been more and more used for the test running of renovated car motors.

Methods of Limiting Gas Consumption

Speed is perhaps the attribute which, above all, has promoted the domestic use of gas. In normal times this speed has been increased at the expense of efficiency. To make use of this reserve of efficiency, pressure in the distribution system was decreased at the beginning of 1941 from the normal 2⅜ in. w.g. to 1¼ in. throughout the whole country. By this means a saving of 5 to 10% of the domestic gas consumption was achieved. Later, the specific gravity of the gas was increased and at the same time the calorific value was decreased so much that in 1945 the gas-works had to bring the pressure up to a normal figure again. On account of the reduced gas pressure the efficiency of many industrial gas appliances was forfeited. It might even happen, that the necessary temperature could not be reached. To increase the pressure in these cases separate gas blowers had to be installed. These blowers continue to give good service during the present bad conditions in respect of the specific gravity and calorific value of the gas.

In collaboration with the authorities the Gas Industry has carried out two great campaigns for the saving of gas, which have been aimed at both domestic and industrial consumers. In spite of efforts to limit gas consumption and to procure new raw materials for gas production, the coal ration has not been sufficient for every gas-works. The possibility of adding water gas was considered to be limited by the increasing toxicity of the gas. Consequently it has been necessary even to ration gas, and this was done on April 16, 1945. At present, gas is rationed at 10, out of 37, gas-works in Sweden. These 10 gas-works, however, represent about 80% of the total capacity of the

* From "The Gas Industry Overseas, 1939-45." Communication No. 299 of the Institution of Gas Engineers.

Gas Industry. Domestic consumers receive about 70% of their previous consumption, while more is allocated to industrial consumers.

The hardness of the coke has become worse in proportion as increased quantities of non-caking coals have been used. The quantity of breeze has increased to an average of about 30%. The coke pieces, obtained from the carbonization of uncrushed coal, are almost of the same shape, but smaller in size than, the coal charged. This coke may be used for coke-fired boilers. The bigger uncrushed pieces of shale, however, cannot pass through the grates, and are thus causing a great deal of hard work for the firemen.

New Products

Already before the war, the Stockholm Gas-works had a benzole plant, including a rectifying plant. At the end of 1940 new benzole plants were started at seven other large gas-works; also a rectifying plant at Göteborg Gas-works, intended for the crude benzole from all the new plants. In this way the benzole capacity of the Gas Industry was nearly doubled.

The Stockholm Gas-works has also started production of various new by-products, *e.g.*, crude phenol, carbolic acid, cresol and pure pyridine.

The relationship between prices of coal and coke in Sweden is generally such that the income of gas-works from coke is about the same amount as the cost of coal. As early as 1939, the price of coal was rising greatly and more rapidly than the price of coke. On account of this, the price of gas was forced up to about twice that obtaining before the war. In 1940, the prices of coal and coke, however, were regulated by the Authorities, and fixed at about twice the pre-war figures. Thus the relationship between the prices was brought back to the normal level, and the increased gas prices again could be reduced. Present gas prices are still, however, quite 50% higher than the pre-war prices. It has not been possible to lower them more, on account of the decreased output of coke. In the second half of 1945, when importation of coal could be resumed, the price of coal was increased about 40% by comparison with the war price, but the price of the coke produced by gas-works remains restricted by the authorities to the same level as during the war. This artificial and abnormal relationship of prices is, of course, a great burden on the economy of the Gas Industry. Even during the past years the procuring of substitute materials for gas making has caused many extra costs. The economy of the Gas Industry is very much strained by all these factors.

The Future

The fact that the Swedish Gas Industry has to import all of its coal, while the waterfalls of the country are not yet half utilized for the production of electric power, has been used during the past decade in propaganda for domestic cooking by electricity. However, the Gas Industry has replied that it is more favourable to import coal for producing gas and coke within the country than to be compelled to substitute coke production at gas-works by increasing coke imports and at the same time to lose the gas. In spite of gas rationing, and the inferior quality and high price of gas, the Gas Industry has made good progress in competition during the past years. The fact is, however, that gas as a domestic fuel is hard pressed at present, and the Gas Industry looks forward to the time when coals suitable for gas and coke production may again be imported in sufficient quantities, so that gas rationing may be abolished and gas quality improved. There is every indication that as soon as the relationship between the prices of coal and coke becomes normal again, it will be possible for us to resume the future evolution of the Swedish Gas Industry in the same way as before. No doubt the experiences of the war years will then help us to achieve this aim.

High-Pressure Gasholders*

By G. M. GILL,
M.Inst.C.E., M.I.Mech.E.

IT has been somewhat surprising to the Author that there has not been more development in the use of high-pressure gas storage vessels in this country, seeing that there are many advantages in their use as compared with the normal low-pressure holder.

In contrast with low-pressure holders, the initial cost of high-pressure holders decreases, per 1,000 cu.ft. stored, to a comparatively small extent as the size is increased. It thus becomes practicable from the economic standpoint to install high-pressure holders in small units, more or less in accordance with the growth in the sales of gas. Due to lack of any lengthy experience, it is not possible to make a reliable estimate of the upkeep and depreciation costs of high-pressure holders, but the Author would suggest that it is doubtful whether the cost of these items will amount to one-quarter of what is normal in the case of low-pressure holders.

Some reference should be made to the pioneer work which Mr. George Helps did, many years ago, in various parts of the country. In one works of the Author's group he installed a high-pressure holder or receiver with a capacity of 9,000 cu.ft. at a pressure of 80 lb. per sq. in. From this small holder were eventually laid about 15 miles of high-pressure main of 4 in. or less. For some years this holder, small as it was, was large enough to supply the high-pressure district at 3 to 6 lb. per sq. in. for a period of several hours a day. It was then merely necessary to refill the high-pressure holder, which work was automatically carried out by a compressor. This system enabled sparsely populated areas, outlying villages and so on, to be given a supply of gas which by any other means would have involved too high a capital outlay. This system, in the Author's opinion, has not been adopted as widely as might have been done to advantage.

Uses for High-Pressure Gasholders

There are many uses for high-pressure holders. These lend themselves admirably to reinforcing gas pressure in awkward parts of a district, it being quite practicable to arrange for automatic maintenance of gas pressure in such places at peak load hours. Thus, with these outlying high-pressure holder stations the gas compressors will automatically go to work during night hours to fill the high-pressure holders. When a predetermined pressure is reached in such vessels, the compressors are automatically stopped, while by further automatic means the high-pressure holders will deliver gas into the mains when the pressure therein reaches a predetermined level, and will continue to feed gas into them until a maximum predetermined level is reached.

Plant for carrying out these requirements has been installed in various parts of the country, and of these the Author is familiar with those installed a few years ago by the Shrewsbury Gas Light Company, where this type of plant has been of considerable value, and has solved a problem which would have been considerably more expensive if carried out by low-pressure holders. This type of plant avoided the objections, possibly serious, which would have been raised to the erection of a low-pressure holder in a residential neighbourhood.

Similar plant was installed at the end of the Stroud Gas Light and Coke Company's area to feed an awkward district at times of high demand, but this was removed when the same Company arranged to take a supply of bulk gas from the Gloucester Gas Light Company a few years later. In this case the Gloucester gas was delivered into this end of the Stroud Gas Light and Coke Company's mains. The plant discarded by the Stroud Gas Company has now been installed at a remote point in a large rural area supplied by the Cheltenham and District Gas Company.

These automatically operated high-pressure holders with their ingeniously arranged compressing plant will undoubtedly be used to a considerably greater extent in the future, as such a system has notable advantages over that used in the past.

Another useful purpose can be served by high-pressure holders replacing low-pressure holders where the latter are out of use due to accidents or to the need for complete overhauls. Such vessels have been used in two cases in works controlled by the Author, to enable extensive repairs to be carried out. In one case it was the only holder in the gas-works; while in the other case the larger of two holders, amounting to 85% of the total storage, had to be put out of use for many weeks. In each case the gas supply was for the whole period maintained satisfactorily by the temporary use of two small high-pressure holders containing in all 14,000 cu.ft. at 80 lb. per sq. in.

In the first case, the district supply had to be maintained entirely for some weeks from the high-pressure holders. This was done by using the compressor in place of the works exhauster, and by pulling the gas through the washing and purifying plant before entering the high-pressure holders. By means of a by-pass governor on the compressor a steady vacuum was maintained in the retort house. This is a method adopted in California, where the gas supplied was for many years made in oil-gas plants of the "run and blow" type, with a relief holder as with water gas plants. Seeing that it was also a practice in some cases to store gas in high-pressure holders, it was necessary to use compressors instead of exhausters and to place these between the purifiers and the high-pressure holders.

The other case where high-pressure holders were of great service for temporary use was in a 25 mill. cu.ft. capacity gas-works where there were two gasholders, and where the larger of the two, amounting to 85% of the total storage, had to be put out of use to enable extensive repairs to be carried out. In this case also the same two high-pressure holders as were used in the former case were installed to operate with an existing and small low-pressure gasholder of 11,000 cu.ft. capacity. Here again the gas supply to the town was maintained satisfactorily throughout the period. In this latter case, the high-pressure holders were connected to the crown of the low-pressure holder by means of a

* Communication No. 296 to the Institution of Gas Enginners.

2-in. heavily armoured flexible pipe, so permitting the low-pressure holder to rise and fall freely. This has been the normal and permanent method of working high and low-pressure holders in combination.

The normal method of working high-pressure holders in gas-works is to fill these when there is gas to spare, and sometimes at night. When full these are then frequently left for days, or possibly for weeks, while the low-pressure holders do all the work. If there is a cold spell, a breakdown in the works, or a shortage of gas from any cause, then the high-pressure holder empties its gas into a low-pressure holder, or direct through a governor into the district mains. It will be realized that gas stored in this way can be much more convenient than that stored in the upper lift of a 3 or 4 lift holder. For the reasons stated it should be understood that normally in practice the proportion of gas compressed is quite a small percentage of total production, which explains why compression charges are so moderate in amount.

Operating and Maintenance Costs of High-Pressure Gasholders

As many members will realize, it is difficult to arrive at accurate costs in small works, and therefore the Author does not propose to give anything detailed about operating and maintenance costs for high-pressure gasholders, but it may be stated that at no time has he been other than surprised at the modest cost of running these installations. In no case has any manager criticized the cost of operation, or even referred to it as an important item of expenditure. (It might here be pointed out that in the items of expense there is little but power which can be termed as important.)

In this connexion attention may be drawn to the statement of Mr. L. B. Chapman, then Engineer and Manager of the Skipton Gas Undertaking, in the discussion of Mr. Escreet's Paper on "The Design of Distribution Systems to Supply Post-War Development," at the 80th Annual General Meeting (1943) of the Institution of Gas Engineers.

Mr. Chapman at that time informed the meeting that the Skipton high-pressure holder of 250,000 cu.ft. capacity, in use since 1933, with a working pressure of 50 lb. per sq. in., had only cost his undertaking £200 for maintenance over a period of 10 years, or less than 0.01d. per therm sold.

The thickness of plates used (mainly from ¼ to 1 in.) is from four to eight times the thickness of gasholder sheeting, and we know from experience that many low-pressure gasholders have had a long life. Many in normal use to-day are considerably older than anyone in this room. It is found by experience that, due to the oil used in the gas compressors, there is an oil film on the inside of high-pressure holders, which will doubtless protect this part of gasholders from corrosion over a very long life.

With low-pressure holders there are various factors such as:

(1) Up and down movements in water.
(2) Icing of water lutes and tanks; provision of boilers and somebody to operate them.
(3) Damage from chemicals and solid deposits.
(4) Damage from very high winds.
(5) Damage or destruction by enemy action.
(6) Corrosion of sheet metal and working parts.

All the above factors increase the care necessary to keep this type of plant in good condition. All of these adverse conditions can, and do, shorten the life of gasholders and increase wear and tear and depreciation, particularly if the holders do not receive constant and regular attention.

In the case of high-pressure holders, most of the above factors are absent or present to a much smaller extent, which should result in greatly reduced maintenance cost; while it should not be overlooked that gas supplied from high-pressure holders is more or less dry.

High Cost of Small Low-Pressure Gasholders

The cost of new low-pressure holders per 1,000 cu.ft. stored decreases fairly rapidly as the size of the holder is increased. It is these small and relatively expensive holders which have to be used in the majority of the 1,200* or more gas-works and gasholder stations of this country.

In his own experience with gas companies of the Severn Valley Gas Corporation, Ltd., and of Gas Consolidation, Ltd., the Author has found that in many small works holder capacity is one of the pronounced weaknesses, often being small in amount, while frequently throwing too low a pressure. When increased sales of gas necessitate the provision of more holder capacity, it has been found that the capital cost of small holders has been proportionately so substantial that some other solution was sought, with the result that high-pressure holders have been installed in a number of these cases.

Considering that there are well over 500 small works which are making less than 50 mill. cu.ft. of gas per annum in England, Wales, and Scotland, the Author suggests that in such and larger works the installation of high-pressure holders may often prove to be a solution to problems which might otherwise involve undertakings in unduly high capital outlay, and in some cases place them and their finances in an awkward position.

Insurance of High-Pressure Gasholders

The engineer wishing to install a high-pressure holder will find that some of the engineering insurance companies are likely to impose somewhat severe restrictions on construction, particularly in the case of welded storage vessels. It is, of course, understood that extra care is required with high-pressure holders of welded construction, and it is desirable, if not essential, for an engineering insurance company to inspect regularly the materials and workmanship throughout the carrying out of the contract.

This practice was followed recently in the case of a high-pressure holder installed in one of the Author's works, with a result satisfactory not only to the insurance company, but also to the builders and the Gas Company. The cost of such inspection work was quite reasonable, and amounted to less than 1% of the total capital cost of the vessel. It was stipulated that this particular holder, which was 60 ft. 8 in. long by 10 ft. diameter, to contain 31,000 cu.ft. at its working pressure of 100 lb. per sq. in. (normally 80 lb. per sq. in. is the maximum used in this particular works), should be tested with a hydraulic pressure of 150 lb. per sq. in. This was carried out quite successfully, and the holder remained perfectly watertight throughout. In this particular case the high-pressure holder was of arc-welded construction, and the engineering insurance company meticulously examined during construction the general welding work and that of the individual welders employed. That they were satisfied is shown by the fact that the annual premium is less than £5 a year for a cover of £20,000.

Difficulties with Large High-Pressure Gasholders

A few comments respecting high-pressure holders generally will not be out of place in this Paper. With large high-pressure holders the problems which arise are much more complex than with the small vessels. It is not proposed to attempt to turn this Paper into a learned dissertation on strains and stresses in these holders; but the Author believes that the more one studies this matter, the more complex it becomes.

Engineering insurance companies are critical of large welded storage vessels for use with high pressure. Means for the inspection of the welded joints are not readily practicable. X-ray methods are not favoured even if these were available. Nevertheless, some of us, the Author included, would much prefer a welded to a riveted holder. As a consequence, some insurance companies will not allow as high a joint efficiency with welded as with riveted joints. This entails thicker plates being used. With plates approximating to 1 in. in thickness the work is expensive, and increases materially with increased thickness of plate. There is also the question of testing the holder upon completion. When filled with gas it is very light. The loading of the foundation will be no more than, say, a few cwts. per sq. ft., but when filled with water for testing, the loading on the foundations is increased by, say, 6 to 11 times, varying with the diameter of the vessel.

This, of course, may not be very serious, nor are the foundations likely to be a heavy expense with high-pressure holders, and certainly nothing like the cost with low-pressure holders. It is practicable to support the holder temporarily, when filled with water and ready for hydraulic test, by means of baulks of timber, to assist the permanent foundations. However, it is not the foundations which are the serious consideration when carrying out the hydraulic test, nor provision and disposal of the water, but the weight of the water in the vessel itself when used as a tank.

A high-pressure holder measuring 102 ft. long by 32 ft. diameter, to store 250,000 cu.ft. of gas at 50 lb. per sq. in., will contain 2,050 tons of water when ready for the hydraulic test. This strain on the vessel is considerably greater than will be the case when it is filled with gas at high pressure. Consequently the holder has to be designed not only for containing gas at high pressure, but also for use as a water tank, which latter requirement entails materially greater strength of construction and a substantially higher cost to build.

The builders of high-pressure holders of, say, 250,000 cu.ft. in capacity quote two prices, (*a*) for air testing, and (*b*) for hydraulic testing, with (*b*) about 20% to 25% higher than (*a*). This increase does not include the cost of providing the water and its disposal, nor the permanent or temporary strengthening of the foundations; but, normally, this cost would not be a very important item of expenditure. The Author cannot at present suggest any means of overcoming these difficulties and the increased expenditure on the large high-pressure holder, solely due to the necessity for this to be strong enough for it to be used as a water tank for a short period. It should be made clear that this disadvantage does not arise with small high-pressure holders. In this connexion it may be pointed out that the excessive strain placed upon the vessel, due to its holding water instead of gas, is equivalent to one-half in lb. per sq. in. of the diameter of the cylinder. Thus for a holder of 10 ft. diameter it merely has to be strong enough to withstand an extra pressure of 5 lb. per sq. in. when filled with water as compared with that when filled with gas. This small difference can almost be ignored when designing the holder. It is a very different story with a vessel of, say, 32 ft. diameter. Further, a vessel of 10 ft. diameter, constructed for a working pressure of 100 lb. per sq. in., will need cylindrical plates of ⅜ in. thickness, with dish-ended plates ⅝ in. thick at the two ends of the holder, or of quite modest thickness for a high working pressure.

It comes to this, therefore, that vessels great in length and of small diameter have considerable advantages over those which are small in length and large in diameter. Accordingly the Author would advise that consideration should always be given to the practicability of

* There were before the war approximately 3,240 low-pressure gasholders in England, Scotland, and Wales.

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installing a number of small vessels, each of considerable length, rather than one large vessel. This appears to have been the practice adopted in some Californian gas-works. In adopting such a practice, there is, of course, the advantage that the capital expenditure can keep pace with the increase in the sale of gas; while there is also an advantage in doing this to facilitate taking these vessels out of service for internal inspection, though it is the Author's opinion that this will very rarely be necessary when more experience has been gained of this type of plant.

Spherical High-Pressure Gasholders

The Author feels that he should make some reference in this Paper to the use of spherical holders, known in America as "Hortonspheres," in comparison with cylindrical vessels with hemispherical ends. With the sphere, calculations show that for a given pressure the thickness of the plates needs to be only half that of those used for the longitudinal plates in the case of cylindrical vessels of the same capacity. Consequently, spheres can be constructed with plates of considerably lighter weight than cylindrical vessels. Further, the supports upon which a sphere rests require no provision for expansion or contraction. A sphere therefore has advantages over vessels of other shapes, but it should be pointed out that the construction of the sphere requires considerable skill on the part of the builder. This, however, should not rule out its adoption in the future.

It is somewhat strange that the spherically shaped vessel does not appear to be favoured in this country, although in America there is a large number in use. Probably this is mainly due to the fact that George Horton, who developed the Hortonsphere, was a man of considerable energy and skill, not only in designing and building such vessels, but as a salesman.

Small High-Pressure Gasholder Installations

The following descriptions of small high-pressure gasholder installations in gas works controlled by the Severn Valley Gas Corporation, Ltd., and by Gas Consolidation, Ltd., demonstrate the usefulness and flexibility of these units. It will be seen that for moderate outlay the storage capacity of a plant constructed for rural needs of a generation ago may be increased to meet a growing demand; while at the same time the high-pressure factor may be used to maintain mains pressure throughout distribution systems extended to cover new development areas.

Malpas Gas-Works

This little works upon acquisition in 1936 was only making 3.7 mill. cu.ft. per annum. It had an 8,000 cu.ft. low-pressure gasholder. Its maximum day was said to be 22,000 cu.ft., and, consequently, there was only 8.7 hr. storage on the maximum day—an uncomfortable position.

The works was entirely rebuilt with discarded but good plant from other small works which had been shut down, while there was added a good design of retort setting with four retorts. A second-hand air receiver was bought to hold 6,000 cu.ft. at a working pressure of 80 lb. per sq. in. There was also installed a Reavell single-cylinder, single-acting compressor with a capacity of 1,000 cu.ft. per hr. at 80 lb. pressure, coupled direct to a 5 h.p. vertical gas engine. By this means, the storage capacity has been increased to 12.6 hr. on the present maximum day of 26,000 cu.ft., while the same plant is now dealing with 6.65 mill. cu.ft. per annum. There has been no trouble of any kind with this plant since it was installed nine years ago.

The high-pressure holder is connected to the crown of the low-pressure holder by a 2 in. heavily armoured hose-pipe. The high-pressure holder has also a Waller reducing governor to enable it to supply the district direct if necessary. Further, this device enables increased gas to be supplied during peak load times. The whole of the high-pressure plant being mostly second-hand, cost £250, which was a mere fraction of the cost of a new low-pressure holder and tank.

Market Drayton Gas-Works

In this works, making 19.6 mill. cu.ft. per annum when acquired in 1936, there was a very old and weak single-lift gasholder with a capacity of 24,000 cu.ft. and two small two-lift holders, each with a capacity of 12,000 cu.ft., making a total storage capacity of 48,000 cu.ft., or 19.5 hr. on the maximum day of 59,000 cu.ft.

It was decided because of the weakness of the largest holder to install two old Lancashire boilers after converting these to high-pressure holders with a total capacity of 20,000 cu.ft. at 100 lb. per sq. in., for which they were insured. This increased the storage capacity, at a total cost of £540, to 27½ hr. on the maximum day. This plant was operated by a twin-cylinder single-acting compressor with a capacity of 2,400 cu.ft. per hr. at 100 lb. pressure. The compressor was driven by a 14 h.p. National gas engine.

Recently, due to an increase in the production of gas to 29 mill. cu.ft. per annum, there has been added another high-pressure holder of cylindrical shape, 62 ft. long by 10 ft. diameter, built by the Oxley Engineering Company, with a capacity of 31,000 cu.ft. at 100 lb. pressure. This is a welded holder and cost £2,072, including foundations. There was also installed a new Reavell twin-cylinder single-acting compressor with a capacity of 4,500 cu.ft. per hr. at 100 lb. pressure. This was driven by a 20 h.p. electric motor. This compressing plant cost in all £420, including foundations and a compressor house, and now operates the three high-pressure holders, with the old compressing plant as a stand-by. The new plant therefore cost in all £2,567.

To show how low the cost of compression is in actual practice, it might here be stated that for the quarter ended 31st December, 1945, only 147,000 cu.ft. of gas were compressed into the high-pressure holders. The consumption of electricity was 441 units, for which at the price paid for current, *i.e.*, 1d. per unit, the cost to the Market Drayton Gas Company was 36s. 9d. only.

Tenbury Gas-Works

The Tenbury Gas-works, upon acquisition by the Company in 1935, was making 8.7 mill. cu.ft. per annum, and was served by two gasholders, one of 24,000 cu.ft. capacity with two lifts, and one with a single lift of 12,000 cu.ft. capacity, making a total of 36,000 cu.ft. for a maximum day of 40,000 cu.ft. or 21.7 hr. storage.

A new industrial consumer placed a considerable load on the Company during the war, so it was arranged to transfer the portable high-pressure installation (to which reference is made elsewhere in this Paper), consisting of two receivers with a total capacity of 14,000 cu.ft. at 80 lb. pressure, to the Tenbury Gas-works. This plant is operated by one single-acting compressor which is driven by a 7 h.p. gas engine, and has a capacity of 1,800 cu.ft. per hr. at 80 lb. pressure.

This gas-works made 20.1 mill. cu.ft. in 1945, so it was decided to increase the high-pressure storage to 50,000 cu.ft. by adding four more converted Lancashire boilers and installing a 2,500 cu.ft. per hr. Reavell compressor, driven by a 12 h.p. electric motor. There is also the original compressing plant to act as a stand-by. This addition was also rendered essential by the fact that the larger of the two low-pressure holders has shortly to be shut down for an extensive overhaul, and will be out of commission for some months. This works will then be operated with 12,000 cu.ft. of low and 50,000 cu.ft. of high-pressure storage. This will be the third works to be operated wholly or mainly by high-pressure storage.

Stourport Gas-Works

This works, when the Stourport Gas Company was acquired in 1935, was making 46 mill. cu.ft. per annum, and had a holder capacity of 108,000 cu.ft. or 14.5 hr. on its maximum day of 179,600 cu.ft. A two-lift holder of 60,000 cu.ft. capacity was installed in 1936, in an old holder tank, to cope with increasing sales.

In 1943, the Company's storage capacity on a maximum day of 408,000 cu.ft. was only 9.4 hr., and it was accordingly decided to install a welded high-pressure holder (85 ft. 9 in. long by 20 ft. diameter) of cylindrical shape with a capacity of 100,000 cu.ft. at 60 lb. per sq. in. This was built by Clayton, Sons & Co., Ltd., and cost £5,572, including foundations, while the compressing plant, made by Bryan, Donkin & Co., consisted of one 8,000 cu.ft. per hr. vertical compressor. This plant is driven by an electric motor and cost £722, including foundations. The total cost of the whole plant, including mains and laying and governors, was £7,064.

Although this high-pressure holder comprises 40% of the total gasholder storage, which even now only amounts to 15 hr. on the present maximum day of 432,300 cu.ft., it is only costing the company about £15 per annum for electricity since the plant went to work in October, 1944.

This Company's load is an awkward one, 44% of the gas being used by industrial consumers taking the whole of their supply during 5½ days a week, and most of that during daytime only. In the case of this works, one important consideration was that there was no suitable land for a low-pressure holder. Even so, there have been no regrets that the decision was made to install a high-pressure vessel.

The above work was carried out in its entirety and without help from Headquarters by the Engineer and Manager of the Stourport Gas Company, Mr. E. H. Greenaway.

Bromyard Gas-Works

The Bromyard Gas Company, Ltd., when acquired, in 1935, had an annual production of 10.7 mill. cu.ft. with a maximum send-out of 51,000 cu.ft. There was a single-lift holder with a capacity of 28,000 cu.ft. Consequently its storage capacity was 13.1 hr. on the heaviest day. This annual production has now increased to 13 mill. cu.ft., although its maximum day remains the same.

To reduce night work and to safeguard the supply, particularly as one holder is never satisfactory, it has been decided to install a high-pressure storage plant consisting of two converted Lancashire boilers, each 30 ft. long by 7 ft. 6 in. diameter, at a working pressure of 80 lb. This will provide an additional storage capacity of 14,420 cu.ft. The compressing plant will consist of a 9 h.p. vertical gas engine direct-coupled to a Reavell single-acting compressor with a capacity of 1,800 cu.ft. per hr.

Chepstow Gas-works

The Chepstow Gas Company's Works, when acquired in 1936, had an annual production of 23 mill. cu.ft. and a storage capacity of 52,000 cu.ft., or 14 hr. on a maximum send-out of 89,000 cu.ft.

The works was closed in 1939, and a bulk supply was taken from Newport (Mon.) Gas Company, which itself was taking coke oven gas. Its send-out of gas has now increased to 67.5 mill. cu.ft., while its

maximum day is 220,000 cu.ft., with the same storage capacity providing only 5.6 hr. on the heaviest day.

It has now been decided to install three 30 ft. long by 8 ft. 6 in. diameter converted Lancashire boilers to operate at a maximum pressure of 100 lb. per sq. in. This will give an additional storage capacity of 34,000 cu.ft. Normally it will be operated at 80 lb. pressure.

This plant will be operated by a Reavell two-cylinder, single-acting compressor with a capacity of 5,000 cu.ft. per hr. at 80 lb. pressure, and driven by a 22 h.p. electric motor. This high-pressure plant is a preliminary to the addition of a low-pressure holder of substantial size.

Skipton High-Pressure Gas-holder

The Author co-operated, as Consulting Engineer, with Mr. N. B. Thompson when he pioneered the installation of the large high-pressure gasholder in this country, which was erected at Skipton in 1932. This vessel had a capacity of 250,000 cu.ft. at 50 lb. pressure, and was of cylindrical shape, 102 ft. long by 32 ft. diameter. At that time it was necessary to obtain the consent of three Government Departments to this installation, as a holder of such size was then a novelty in this country, although many were in use in other countries, notably in the United States of America.

At Skipton the high-pressure holder was required not only to augment the existing low-pressure storage capacity, but also to act as a storage vessel while the large gasholder was put out of commission for overhaul. It was further required to supplement the supply of a growing district.

It was originally proposed to construct this holder with internal framework attached to the shell, but, following experience in America, this design was altered whereby no internal framework of any kind was attached to the inside of the vessel, such support being confined to the use of circular-shaped and independent framework, termed " spiders," with a diameter slightly less than the cylinders and maintained vertically by means of angle-iron cleats riveted to the cylinder. The object of these spiders was merely to support the cylinder in its circular shape when it was empty, as otherwise it would be liable to sag if unsupported. The holder was supported on one fixed cradle, while the remaining cradles were supported on rollers, so allowing the cylinder to expand and contract without throwing any strain upon the vessel.

This type of design had been developed by Stacey Brothers, of Cincinnati, U.S.A., as the result of experience in the building of these high-pressure vessels, and the Author was at that time indebted to this firm for information which led to this form of construction in the case of the Skipton holder.

In presenting the Paper, Mr. Gill added:—Quite recently I came across an account of the design and construction of four very large high-pressure gasholders in the U.S.A. These vessels were each of 500,000 cu.ft. capacity at 50 lb. pressure. They were welded throughout and were made of high tensile steel. The cylindrical portion was 0.81 in. thick and the semi-spherical ends were 0.41 in. thick. They were tested under air pressure to 60 lb. per sq. in. To carry out the testing, the vessels were first of all covered with soap and water and tested for leaks at 5 lb. pressure. The welds were then painted with lime wash which, when dry, forms a brittle surface. The pressure was then raised by 5 lb. per sq. in. at a time and all the welds were examined for cracks, and any that appeared were, of course, repaired. Finally, the vessels were tested by the Magnoflux method, which is quite new to me. By this method, each portion of the plate is magnetized whilst a ferro-magnetic powder is sprinkled over the joints. If there is a crack or a defect, this is disclosed by the powder building up in the form of a ridge at the defective place. These four very large high pressure holders were tested under the Code of the American Petroleum Institute and the American Society of Mechanical Engineers. I refer to these holders particularly because they have only just come to my notice and it may be that this careful and methodical examination, step by step, may prove to be the solution of the problem of the testing of these very large high-pressure holders.

DISCUSSION

Mr. F. M. **Birks** (Managing Director, Gas Light and Coke Company):—It is a great pleasure to have the opportunity of joining in a discussion on a paper by Mr. Gill. Nearly half the area of supply of the Gas Light and Coke Company is not densely populated and consists of a number of small country towns each of which was at one time supplied by its own works, but which now receive their gas supply from a grid system working at a pressure of about 60 lb. per sq. in. Some of the works were very small, and until recently there was in use an original holder with a capacity of only 5,000 cu.ft. It will be appreciated, therefore, that large undertakings can also be interested in this matter.

Apart from two small pressure receivers at Grays, the first high-pressure holder on our district was put into use in 1935, and since then two others have been added and a fourth will be installed as soon as possible. It is unlikely that the use of pressure holders would be considered except for the smaller sizes in which the weight of steel used may be less than that of the water-sealed bell type.

It is suggested by the Author that the high pressure holder has an advantage in so far as that all the stored gas can be made available, whereas it is frequently difficult to use gas stored in the top lift of a water-sealed holder.

In point of fact there is about the same percentage of gas locked up in the pressure vessel and this cannot be made readily available, as can be done in the other case by the installation of a simple pump. Our experience confirms certain difficulties in design referred to by the Author, the solution of which may lead in the future to the use of somewhat higher pressures than four atmospheres. The pressure could be raised to 16 atmospheres with only about twice the power consumption.

Such an increase would enable standard vessels to be constructed in the workshop of a size to allow them to be transferred complete to the site, would simplify the hydraulic test, cheapen foundations and reduce the quantity of locked up gas to 25% of what it is at present. It would probably lead to the use of multiple vessels, an advantage to which the Author has drawn attention.

As the weight of mild steel in a pressure vessel of any given shape is a function of its capacity for the storage of free gas, there should be neither increase in weight nor presumably cost.

Birmingham Installation

Mr. G. C. **Pearson** (President-Elect; Engineer-in-Chief, Birmingham Gas Department):—We are putting up our first high-pressure installation in Birmingham and the work has been in the hands of our Distribution Engineer, Mr. Marsh. I understand he is preparing a description for the technical Press quite apart from this Paper but, of course, there is no reason why I should not give some of the information with regard to the installation. We have a district around the Austin Company's factory at Longbridge that suffers from low pressure at certain times, mostly on Sundays at cooking time and we want to improve these pressures. The district is a considerable distance, about 10 miles, from the gas-works and the provision of an ordinary holder would spoil the amenities of the district very considerably and would only serve just the immediate locality. The pressure at Longbridge is augmented by a high-pressure main at about 15 lb. but at times of very high consumption this high pressure main goes practically down to nothing. Our idea is to have a high pressure holder which can be excavated and put up on the site, to augment the high pressure main, which would mean that we should not only improve the pressure in the immediate locality but we should help the pressure over an area of 80 sq. miles, because of the distribution of the high pressure mains. We are putting down the first of what will be four holders, and the size is rather short of 500,000 cu.ft. The high-pressure holder is 25 ft. in diameter and 200 ft. long, and it is designed to take a pressure of 73 lb., with a blow-up pressure of 81½ lb It will deliver something over 400,000 cu.ft., into the high-pressure main at 15 lb. and will help to augment the pressure throughout an area of at least 80 sq. miles.

As regards cost, of course costs have all gone haywire at the present moment, as you will all know if you have had any tenders in lately. It is more costly than the ordinary holder but it serves a very much more useful purpose in that it augments the pressures over a very large district The holder would have to be designed sufficiently strong to take its test under hydraulic pressure as, of course, if you test it under air pressure you might get a collapse and you would get the explosion you are trying to avoid, straightaway. Therefore, the only way to test is under hydraulic power and that means the holder must be sufficiently strong to stand the weight of the water.

Experience at Shrewsbury

Mr. C. M. D. **Belton** (Shrewsbury):—Mr. Gill asked me if I would contribute to the discussion, as I have had a little experience in the operation of district high-pressure holders. The Author is to be congratulated upon presenting a Paper which (*a*) is not too lengthy to be assimilated in the few days available before the meeting; (*b*) discusses a subject which has not yet received the widespread attention it deserves; and (*c*) concerns some of the problems facing the smallest as well as the largest undertakings. Reference is made to a high-pressure storage station at Shrewsbury, and therefore some further details concerning this may not be out of place.

For many years pressures in some outlying areas have been augmented by special auxiliary mains transmitting gas at 5 lb. per sq. in. pressure from the works to district governors feeding into the low-pressure system. Some eight years ago, however, another area began to develop beyond the capacity of the existing system and it was decided (in preference to laying a large new trunk main from the works) to link up the mains radiating from the centre on that side of the town and build a high-pressure storage station. A suitable site was found on the perimeter and no difficulty was experienced in obtaining the necessary statutory consents, whereas an ordinary type gasholder would have been considered an eyesore and the proposal would have raised serious opposition.

(*To be concluded*)

GASHOLDERS
SPIRAL
WATERLESS
also
RECON-
STRUCTIONS
REPAIRS

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PURIFIERS

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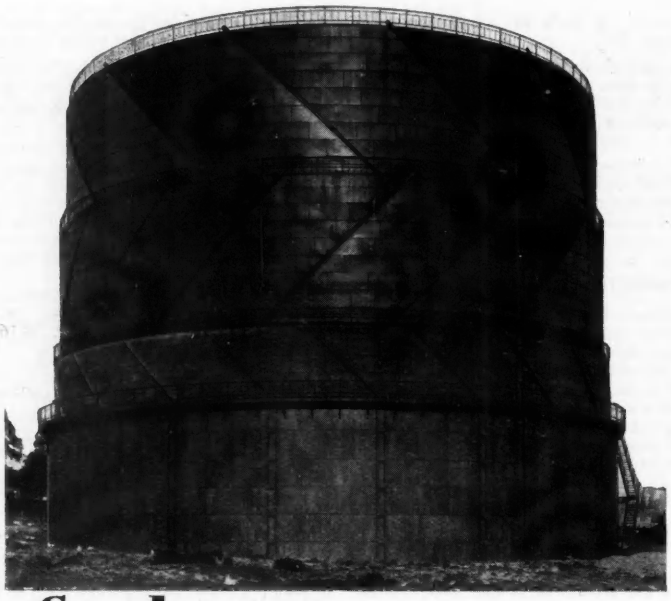
CONDENSERS



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GAS PRODUCTS PRICES

The London Market

August 6.

Effective July 15 there has been an increase of 5s. per ton in the price fixed by the Coal Tar Controller for Coal Tar Pitch in bulk or solid form for the manufacture of Patent Fuel in the home market.

The price thus becomes 75s. per ton free on rail/road waggon/barge or ship, at Makers' Works.

There are no other changes to be recorded in the prices of Coal Tar products.

The Provinces

August 6.

Average prices of gas-works products: Pitch, 70s. per ton; toluole, naked, North, 90's, 2s. 4d. to 2s. 6½d. per gallon; pure, 3s. 2½d. Prices for carbolic acid 60's, anthracene, creosote oil (hydrogenation), coal tar oils (timber preservation, &c.), and strained anthracene oil are controlled by Government Orders. Prices for road tar were increased by a half-penny per gallon by S. R. & O. 1945, 229, under which Order there was also an increase of 5s. per ton in the price for standard creosote-pitch mixture.

Scotland

August 3.

Demand exceeds production and prices are very firm. *Refined Tar.** Yield to the Distiller is 5d. per gallon ex works, naked. *Creosote Oil.* Timber preserving quality,* 5½d. to 6½d. per gallon; Hydrogenation Oil*, 5½d. per gallon; Low Gravity or Virgin Oil,† 7½d. to 7½d. per gallon; Benzol Absorbing Oil*, 6½d. to 8d. per gallon. *Refined Cresylic Acid** is 3s. 6d. to 4s. 6d. per gallon ex works, naked, according to quality. *Crude Naphtha*†, 7d. to 8d. per gallon. *Solvent Naphtha.** Basic maximum prices delivered in bulk, 90/160 grade, 2s. 10d. per gallon, and 90/190 Heavy Naphtha, Unrectified, 2s. 0½d. per gallon; Rectified, 2s. 4d. per gallon. *Pyridine*†, 90/160 grade, 13s. per gallon, and 90/140 grade, 15s. per gallon.

* Price controlled. † Uncontrolled.

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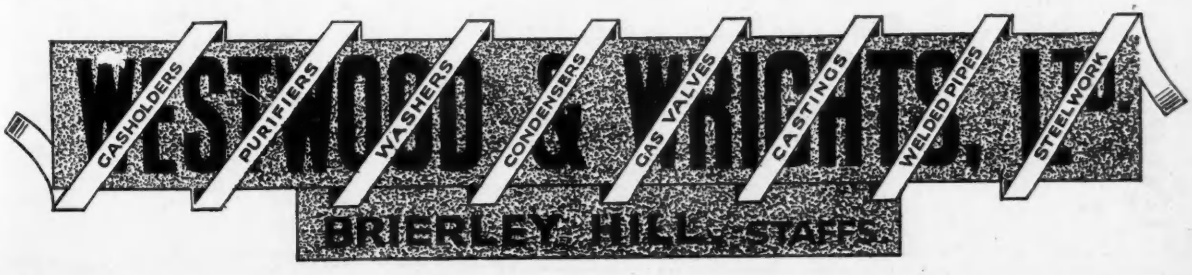
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